

# Snowmobile trauma: 10 years' experience at Manitoba's tertiary trauma centre

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**Introduction:** According to the literature, the increased recreational use of the snowmobile has resulted in an increasing number of musculoskeletal injuries. We wished to examine whether previously described risk factors continue to be associated with snowmobile trauma and to identify previously unrecognized risks and specific patterns of injury. **Methods:** We carried out a chart review of all snowmobile-related injuries over a 10-year period at the Health Sciences Centre in Winnipeg, the only level 1 trauma centre serving the Province of Manitoba, with particular attention to the risk factors of suboptimal lighting, excessive speed and alcohol consumption. **Results:** We identified 480 injuries in 294 patients, and 81 (27.6%) of these patients died. Collisions accounted for 72% of the injury mechanisms. Of the injuries sustained, 31% occurred on roads. Excessive speed was a risk factor in 54% of patients, suboptimal lighting in 86% and a blood alcohol level greater than 0.08 in 70%. Musculoskeletal injuries accounted for 57% of those recorded. There were also brachial plexus injuries (3%) and knee dislocations (2%). To our knowledge, this is the largest study detailing injury associated with recreational use of snowmobiles in Canada. **Conclusions:** Because snowmobile trauma is caused principally by human errors, it is potentially preventable. Efforts aimed at prevention must focus on the driver, who controls the common risk factors. The danger of snowmobiling while intoxicated must be emphasized. Trail-side monitoring is likely to be ineffective, as the majority of accidents do not occur on designated snowmobile trails.

**Introduction :** Selon la littérature scientifique, l'utilisation accrue de la motoneige à des fins récréatives a entraîné une augmentation du nombre de traumatismes musculosquelettiques. Nous voulions déterminer s'il y a toujours un lien entre des facteurs de risque déjà décrits et des traumatismes causés par la motoneige, repérer des risques non reconnus auparavant et déterminer des tendances spécifiques des traumatismes. **Méthodes :** Nous avons procédé à une étude des dossiers sur tous les traumatismes reliés à la motoneige traités en 10 ans au Centre des sciences de la santé de Winnipeg, le seul centre de traumatologie de niveau 1 qui dessert la province du Manitoba. Nous avons accordé une attention particulière aux facteurs de risque liés à l'éclairage réduit, à la vitesse excessive et à la consommation d'alcool. **Résultats :** Nous avons repéré 480 traumatismes subis par 294 patients dont 81 (27,6 %) sont morts. Les collisions ont causé 72 % des mécanismes traumatisants. Parmi les traumatismes subis, 31 % sont survenus sur une route. La vitesse excessive a été un facteur de risque chez 54 % des patients. Dans 86 % des cas, ce fut l'éclairage réduit et dans 70 % des cas, ce fut une alcoolémie de plus de 0,08. Les traumatismes musculosquelettiques ont représenté 57 % des lésions consignées, qui comprenaient aussi des traumatismes du plexus brachial (3 %) et des luxations du genou (2 %). Il s'agit sauf erreur de la plus importante étude décrivant en détail les traumatismes associés à l'utilisation récréative de la motoneige au Canada. **Conclusions :** Comme les traumatismes liés à la motoneige sont attribuables principalement à l'erreur humaine, il est possible de les éviter. Les efforts de prévention doivent converger sur le conducteur qui contrôle les facteurs de risque communs. Il faut insister sur le danger de la conduite d'une motoneige en état d'ébriété. La surveillance sur la piste serait probablement inefficace, car la majorité des accidents ne surviennent pas sur des pistes réservées aux motoneiges.

Originally designed and used as a transportation and work vehicle for inaccessible areas, the snowmobile has become one of the most

popular winter recreation vehicles in North America. In Manitoba it has been estimated that one snowmobile exists for every household.

Before 1990, a number of studies indicated that the growing popularity and use of the snowmobile was accompanied by an increase in the

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number of injuries and deaths. Few reports in the orthopedic literature have examined risk factors leading to snowmobile accidents. A number of studies have suggested that alcohol use, excessive speed and suboptimal lighting are important risk factors.<sup>1-26</sup> Small sample size and varied reporting techniques have led to conflicting evidence of these risk factors. Estimates of alcohol use as a cause for snowmobile-related injury vary from 13%<sup>4</sup> to 80%.<sup>8</sup> Therefore, we decided to review our experience of injuries associated with modern snowmobile use, looking particularly at the risk factors of alcohol consumption, speed and suboptimal lighting.

### Patients and methods

We carried out a chart review of all patients with snowmobile-related injuries admitted to the Health Sciences Centre Hospital in Winnipeg, during the period Jan. 1, 1988, to Dec. 31, 1997. The study population included snowmobile drivers, passengers, people riding on sleds towed by snowmobiles and pedestrians struck by machines.

Data recorded included age, sex, race (Aboriginal or non-Aboriginal) and residence (rural or urban). Careful notation was made of associated alcohol use (recorded in the medical history, physician assessment or measurement of a serum alcohol level above the legal limit [0.08]). The blood sample was obtained as part of a routine trauma blood screening. Alcohol use was also determined by direct admission by the patient (2 or more drinks within 4 h of operation of the snowmobile) (17.6% of patients) or as noted by medical staff, police or ambulance personnel.

Details of the accident setting, including location, speed, time of day and the mechanism of the accident (e.g., rollover, collision, loss of control) were recorded. Speed at the time of accident (61% of charts) was obtained either from the patient's estimated speed (51%), ambulance or

other witnesses (4%) or from police reports (6%). When a collision was found to be the mechanism, note was made of the type of object involved. Patient data included the position on the snowmobile of the injured patient (e.g., driver, passenger), site and type of injury suffered, number of operative procedures and duration of hospital stay. The data were entered into an IBM personal computer for statistical analysis using an SPSS software package. Complete data sets were available on 56% of the charts.

### Results

#### Patient data

The chart review identified 294 patients (260 men, 34 women) who suffered 480 injuries due to snowmobile trauma. The mean age of the patients was 29.1 years, and 62% were aged between 19 and 25 years. There were no children. One hundred and seventy-nine patients (60.9%) were Aboriginal and 115 (39.1%) were non-Aboriginal. Only 41 patients (13.9%) lived in an urban setting; 253 (86.0%) patients lived in a rural setting.

Of the injured patients, 248 (84.4%) were drivers of a snowmobile, with the remaining patients consisting of 28 passengers (9.5%), 6 patients who were riding on sleds being pulled by a snowmobile (2.0%) and 12 patients (4.1%) who were pedestrians struck by a snowmobile.

#### Type of injury

Of the injuries sustained, 57% involved the musculoskeletal system. Other sites of injury were the chest (17%), head (13%) and abdomen (13%). More detailed analysis of the musculoskeletal injuries revealed that injuries around the knee were most common, with femoral fractures making up 17% and tibial fractures 29%. Spine, upper limb and pelvic injuries were also found (Table 1). Within this group, there were a small

number of potentially catastrophic and easily overlooked injuries. Three percent of patients suffered brachial plexus injuries, all from striking a stationary object such as a tree or pole with the shoulder when the patient was thrown free of the snowmobile at high speed. Two percent of the patients suffered knee dislocations, including a concomitant vascular injury in half of them.

On average, 1.6 operative procedures (range from 0-12) were required for each patient, with 74% of the patients requiring at least 1 operation.

#### Alcohol consumption

Alcohol use was associated with 88% of injuries sustained by patients during the 10-year study period. Of the 294 patients, 207 (70.4%) had a blood alcohol level greater than 0.08.

#### Location

Analysis of the accident location revealed that only 16% of accidents occurred on groomed trails designed for use by snowmobiles, and 31% of injuries occurred when snowmobiles were travelling on roads.

#### Speed

Excessive speed was common, with 82% of crashes occurring at speeds

**Table 1**

#### Injuries Associated With Recreational Snowmobile Use

Type/location of injury	Percent of injuries
Head	13
Chest	17
Abdominal	13
Musculoskeletal	57
Upper limb	18
Tibia	29
Femur	17
Pelvis	8
Spine	18
Other	10

greater than 50 km/h. Of these, 38% were travelling at speeds greater than 80 km/h and 16% at speeds greater than 100 km/h.

### Time of day

During the Manitoba winter, sunset occurs between 1600 and 1700, with sunrise between 0700 and 0830. Most commonly, trauma occurred during hours of suboptimal lighting (68%) or after midnight (18%) (Table 2).

### Mechanism

The most common mechanism of injury was a collision (72%) followed by loss of control of the snowmobile (18%) or falling off the snowmobile while it was moving (10%). Further analysis of these collisions demonstrated that almost one-third occurred as a result of the snowmobile striking a mound of snow, covered rock or other type of "bump" (Table 3).

### Discussion

This study represents the most current analysis of trauma associated with recreational snowmobile use. Many of the risk factors identified in previous studies remain. Young male drivers made up the majority of people injured in snowmobile trauma.<sup>1,3,4,6-8,10,13,15,17,19,22,26-28</sup>

A factor that had not previously been examined was the ethnic makeup of injured snowmobile

trauma population. Our study revealed a disproportionate number of Aboriginal patients (60.9% in our study population) who constitute only 12% of the province's population (A. Smith: Vital Statistics and Health Status Section, Health Division, Statistics Canada, Ottawa: personal communication, 1999). This may reflect a preferential referral practice due to the designation of our hospital as the province's official Native health centre. It may also be an accurate reflection of the geographic distribution of snowmobile use in Manitoba. The majority of Aboriginal people in the province live on reserves in the remote northern areas in small isolated communities where the winter season is longer than elsewhere. Our study is also the first to report that the majority (86.0%) of snowmobile accident victims live in rural rather than urban settings, which most likely reflects the geographic distribution of snowmobile use.

This study further documented the prevalence of alcohol consumption in association with snowmobile accidents. In our series, 88% of patients involved in snowmobile accidents had consumed alcohol before the accident. This is the highest rate of alcohol use reported in the literature.<sup>4,8,17,20,21,24</sup> Previous studies have reported rates of alcohol use ranging from 5.4% in a study involving the British Antarctic Survey team members<sup>25</sup> and 12.5% in a North Dakota

study<sup>21</sup> to 69% in an Ontario study<sup>22</sup> and 80% in northern Sweden.<sup>8</sup> Despite warnings regarding the risk of alcohol consumption and snowmobile accidents, alcohol continues to be an important risk factor.

Suboptimal lighting<sup>8,16,20,21</sup> continues to play a significant role in modern snowmobile trauma. With only 12% of accidents occurring during daylight hours, it seems clear that driving in darkness poses a serious hazard. Previous studies have implicated high speed as a significant risk factor for injury.<sup>15,16,21,23,24</sup> Despite the manufacturer's recommended maximum night time speed of 50 km/h, 82% of snowmobiles were travelling faster than 50 km/h at the time of injury. The majority of drivers in our study were travelling in the dark at a speed that "overdrove" the headlights, preventing them from reacting in time.

A number of studies have reported that collisions were the most common mechanism of injury,<sup>4,10,16,21,23</sup> but few recorded the nature of the collision. We found that naturally occurring "bumps" in the snow, such as snow drifts and covered rocks, were the most commonly struck objects. This would correlate with night driving conditions where undulations in the snow are more difficult to see than in daylight. Only one study noted collisions between 2 or more snowmobiles and reported the frequency of this type of collision to be only 6% of the total mechanism.<sup>21</sup> In our study, 18% of collisions (13% of the total trauma) resulted from snowmobiles colliding with one another. This may reflect the fact that snowmobiling is largely a recreational sport and is frequently performed in groups of persons riding in close proximity. We found a 1% incidence of mechanical failure, which agrees with the findings of previous studies<sup>10,16,21,23</sup> demonstrating that snowmobiles are sound, reliable machines and that breakdown is not a major risk factor for injury. Human, not mechanical factors, are the

**Table 2**

#### Time of Day When Recreational Snowmobile Trauma Occurred (n = 294)

Time of day	No. (and %) of patients
Daytime	36 (12)
Evening to midnight*	200 (68)
After midnight†	53 (18)
Unknown	5 (2)
*1600-2359	
†2400-0800	

**Table 3**

#### Mechanism of Recreational Snowmobile injury (n = 213)

Mechanism	No. (and %) of patients
Collision	154 (72)
Another snowmobile	39 (18)
Tree	35 (16)
Car	35 (16)
Fence post	33 (15)
Pedestrian	12 (6)
Loss of control	38 (18)
Fall from snowmobile	21 (10)

cause of virtually all modern snowmobile injuries.

In our study, 16% of collisions involved a snowmobile striking a moving or parked car. No previous study has considered this factor. Furthermore, 31% of injuries occurred on roadways where it is illegal for snowmobiles to travel in Manitoba, except at marked crossings. Only 16% of trauma occurred on marked snowmobile trails, which may indicate that such areas are safer. However, it may also reflect the fact that drivers who are more likely to have accidents seek the thrill of unmarked terrain and roads rather than the less challenging prepared trails. This is an important observation if accident prevention strategies are to be implemented. It is clear that any type of trail-side monitoring to prevent speeding or to check for an intoxicated driver would miss most drivers who are involved in accidents. Our rate of pedestrian injury by snowmobile (4% of all patients) was identical to the rate found in the only other study to examine this phenomenon.<sup>21</sup> Of note is that virtually all of these caused severe injuries of the lower extremity and all involved intoxicated drivers.

The types of injury suffered in snowmobile crashes in our study were consistent with the findings of previous reports.<sup>4,10,13,16,23</sup> Musculoskeletal injury accounted for 57% of the systems injured, with fractures and dislocations occurring in the majority of cases. The lower extremity is almost completely exposed while a person is riding on a snowmobile and is not prevented from striking the ground except by the driver holding the feet on foot rests. The lower limb is also exposed in collisions, as it is the most lateral structure on the sled if it is struck from the side.

We found that 18% of musculoskeletal injuries involved fractures of the spine with approximately half of these resulting in some degree of neurologic impairment. Earlier reports indicated that spinal trauma

was far more common<sup>9,18</sup> in contrast to more recent reports that have shown spinal injury to be much less common, consistent with our data.<sup>6,13,27</sup> This may be the result of improvement in seat cushioning and shock absorbers on modern snowmobiles.

Injuries to the brachial plexus are devastating and rare, but easily overlooked in the acute trauma setting. Brachial plexus injuries occurred in 3% of our patients. All involved patients who were ejected from the machine at high speed, striking a stationary object with the shoulder. All were intoxicated. The literature contains a single report that examines brachial plexus injury in snowmobile accidents and identifies the same risk factors.<sup>29</sup> Knee dislocations occurred in 2% of our cases, all with vascular compromise. These patients often arrive fully clothed in snowmobile suits, and acute awareness is necessary to identify brachial plexus injuries and associated knee dislocation.

In our study 74% of patients required at least 1 operative procedure. This is in contrast to the only other study to examine this parameter. It found that less than half of the patients required an operation.<sup>4</sup>

Previously identified risk factors such as excessive speed, suboptimal light and alcohol consumption continue to be associated with snowmobile-related crash injury. A police surveillance program in Ontario, which involved stopping snowmobiles on trails, appears to have decreased the injury and death rate among snowmobilers.<sup>30</sup> However, the limitation of a trail-based monitoring system is obvious in our study where the majority of accidents occurred away from designated snowmobile trails.

## Conclusions

The recreational use of snowmobiles remains a significant cause of serious injury. Such trauma is caused by human factors and is therefore potentially preventable. Our research

has confirmed that the previously described risk factors of alcohol consumption, excessive speed and poor lighting are still important risk factors. We have identified for the first time a major risk factor: riding on roadways. Trail-side monitoring is likely to be ineffective, as the majority of accidents do not occur on designated snowmobile trails.

**Competing interests:** None declared.

## References

1. Letts RM, Cleary J. The child and the snowmobile. *CMAJ* 1975;113:1061-3.
2. Erskine AL. The epidemiology of snowmobile injuries. *J Trauma* 1970;10:804-6.
3. Gross HP. Snowmobile fatalities in Minnesota. *Minn Med* 1972;55:983-5.
4. Hamdy CR, Dhir A, Cameron B, Jones H, Fitzgerald GW. Snowmobile injuries in northern Newfoundland and Labrador: an 18-year review. *J Trauma* 1988;28:1232-7.
5. Bauer M, Hemborg A. Snowmobile accidents in northern Sweden. *Injury* 1982;10:178-82.
6. Monge JJ, Reater NF. Snowmobiling injuries. *Arch Surg* 1972;105:188-91.
7. Waller JA, Lamborn KR. Snowmobiling: characteristics of owners, patterns of use and injuries. *Accid Anal Prev* 1975;7:213-23.
8. Eriksson A, Bjornstig U. Fatal snowmobile accidents in northern Sweden. *J Trauma* 1982;22:977-82.
9. Withington RL, Hall LW. Snowmobile accidents: a review of injuries sustained in the use of snowmobiles in northern New England during the 1968-1969 season. *J Trauma* 1970;10:760-3.
10. Bjornstig U, Eriksson A, Mellbring G. Snowmobiling injuries: types and consequences. *Acta Chir Scand* 1984;150:619-24.
11. Postl B, Moffat ME, Black GB, Cameron CB. Injuries and deaths associated with off-road recreational vehicles among children in Manitoba. *CMAJ* 1987;137:297-300.
12. Waller JA. A survey of snowmobiling in Vermont. *Accid Anal Prev* 1975;7:207-12.
13. Wenzel F, Peters R. A ten year survey of snowmobile accidents, injuries and fatalities in Wisconsin. *Physician Sportmed* 1986;14:140-9.



14. Dominici RH, Drake EH. Speed on snow: the motorized sled. *Am J Surg* 1970;119:483-6.
15. Kiskinen K. Snowmobile trauma in Finnish Lapland: injuries to the head, face and neck. Possible effects of speed and the use of helmets. *Arct Med Res* 1994;53 (Suppl 3):5-7.
16. Soininen L, Hantula L. Snowmobile accidents in Lapland. *Arct Med Res* 1992;51 (Suppl 7):64-70.
17. Bjornstig U. Accidents in the north: some aspects of snowmobile accidents and moose /car collisions. *Arct Med Res* 1992;51 (Suppl 7):56-8.
18. Chism SE, Soule AB. Snowmobile injuries: hazards from a popular new winter sport. *JAMA* 1969;209:1672-5.
19. Martyn JW. Snowmobile accidents. *CMAJ* 1969;101:35-7.
20. Rowe B, Milner R, Johnson C, Bota G. Snowmobile-related deaths in Ontario: a 5-year review. *CMAJ* 1992;146:147-52.
21. James EC, Lenz JO, Swenson WM, Cooley AM, Gomez YL, Antonenko DR. Snowmobile trauma: an eleven-year experience. *Am Surgeon* 1991;57:349-53.
22. Rowe B, Milner R, Johnson C, Bota G. The association of alcohol and night driving with fatal snowmobile trauma: a case-control study. *Ann Emerg Med* 1994;24:842-8.
23. Lundstrom I, Zetterqvist H, Bjornstig U. Snowmobile injuries in Kiruna, Northern Sweden. *Arct Med Res* 1994;53:189-95.
24. Bjornstig U, Ostrum M, Eriksson A. Would a helmet law for snowmobile riders reduce head injuries? *Arct Med Res* 1994;53:196-9.
25. Cattermole TJ. Snowmobile injuries in Antarctica 1989-1996. *Int J Circumpolar Health* 1997;56:152-8.
26. Beilman GJ, Brasel KJ, Dittrich K, Scatter S, Jacobs DM, Croston JK. Risk factors and patterns of injury in snowmobile crashes. *Wilderness Environ Med* 1999;10:226-32.
27. Lander MG, Middaugh J, Dannenberg AL. Injuries associated with snowmobiles, Alaska, 1993-1994. *Public Health Rep* 1999;114:48-52.
28. Braun BL, Meyers B, Dulebohn SC, Eyer SD. Severe brachial plexus injury as a result of snowmobiling: a case series. *J Trauma* 1998;44:726-30. Erratum, 45:648.
29. Farley DR, Orchard TF, Bannon MP, Zietlow SP. The care and cost of snowmobile-related injuries. *Minn Med* 1996;79:21-5.
30. Rowe BH, Therrien SA, Bretzlaff JA, Sahai VS, Nagarajan KV, Bota GW. The effect of a community-based police surveillance program on snowmobile injuries and deaths. *Can J Public Health* 1998;89:57-61.

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